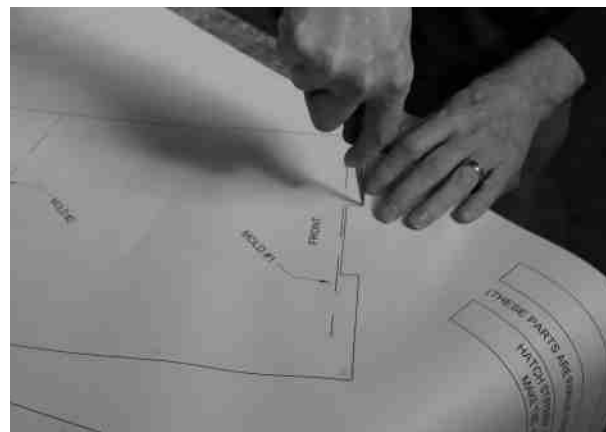


## *Appendix: Building the CLC Teardrop Camper from Plans*



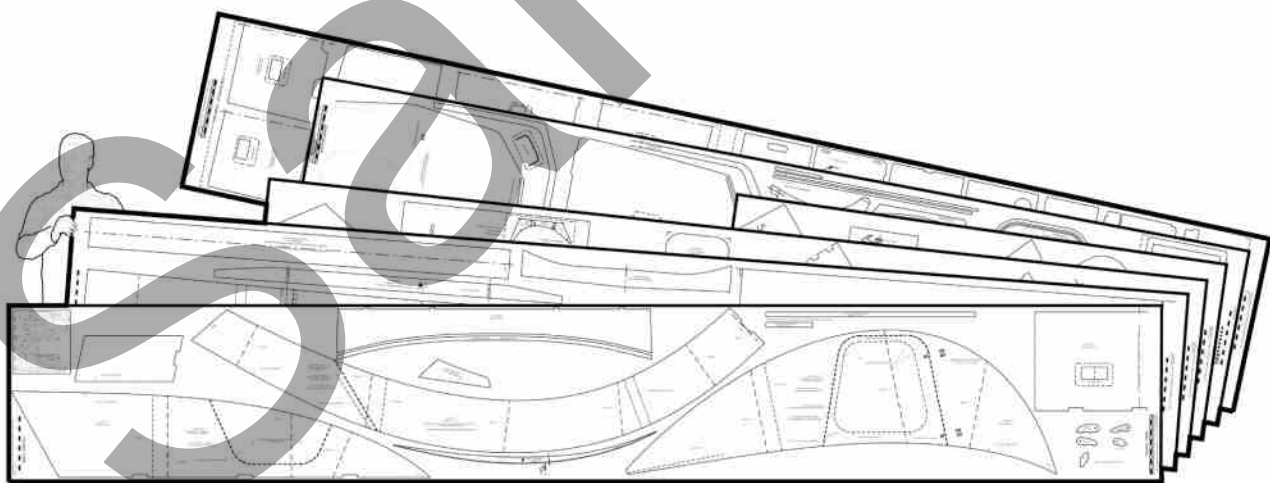
This section is for builders assembling Chesapeake Light Craft's Teardrop Camper from the full-sized patterns.

In these pages you'll find extensive materials lists, wood and epoxy shopping guides, and tips on the accurate transfer of shapes from patterns to wood. The "stitch-and-glue" process used to assemble the CLC Teardrop Camper favors the prefabrication of components. In other words, if you're building from scratch, you'll first create a "kit" of pre-cut parts. Having done that, you'll join the computer-cut kit builders back around Chapter 3 in this book.

Builders starting from scratch should be comfortable with ordinary woodworking tools and with reading plans. The level of detail provided in the manual and patterns is unusually comprehensive, but if you're building from plans you should expect to do some problem-solving in the shop.

This appendix was written by John C. Harris. Jay Hockenberry and John created the illustrations. Editing was by Dillon Majoros, Nancy Noyes, Matt Cordrey, and Blaine Skilling.

Please remember that when buying a kit or a set of plans you are acquiring the rights *to build one camper*. You must buy additional kits or plans and/or get written permission to build additional campers. CLC and the Teardrop Camper's designer retain all rights, including copyright, to the design.



## CLC Teardrop Camper Materials List

Description	Metric Equivalent	Specification
<b>Base Kit: Camper Shell</b>		
<b>Plywood</b>		
5 Sheets 3/16" x 4' x 8'	4mm x 1220mm x 2440mm	Marine Grade Plywood
1 Sheets 1/4" x 4' x 4'	6mm x 1220mm x 1220mm	Marine Grade Plywood
2 Sheets 3/8" x 4' x 8'	9mm x 1220mm x 2440mm	Marine Grade Plywood
2 Sheet 3/4" x 4' x 8'	18mm x 1220mm x 2440mm	Marine Grade Plywood
4 Sheets 1/2" x 4' x 8'	12mm x 1220mm x 2440mm	Construction Grade Plywood
<b>Acrylic</b>		
1 Sheet 1/4" x 2' x 4'	6mm x 610mm x 1220mm	Smoked Acrylic
<b>Epoxy and Fiberglass</b>		
6 gallons total activated (E.G., 4 gallons resin, 2 gallons hardener for 2:1 ratio epoxy)	22.75 liters Or 15.15 liters resin, 7.6 liters hardener	Marine Epoxy
9 pounds Wood Flour	4kg	Medium-density filler
3.5 pounds of "Cell-o-Fill"	1.6kg	High-density filler
2oz CA Glue	60ml	
2oz CA Glue Accelerator	60ml	
22 yards 6-ounce x 50" fiberglass fabric	203 grams/sq. Meter x 127cm x 20.1 meters	Plainwoven E-glass
50 yards 9-ounce fiberglass tape x 3"	305 grams/sq. Meter x 76mm x 45.7 meters	Plainwoven E-glass
<b>Timber</b>		
Galley Flat Stringers: 1 board foot Or 10 lineal feet of 1-1/4" x 3/4"	0.002 cubic meters or 32mm x 18mm x 3050mm	Spruce, pine, or fir
Galley Hatch Drip Catch 45" x 3/4" x 1/2"	18mm x 12mm x 1145mm	Spruce, pine, or fir
Galley Hasp Mounting Block 4-3/4" x 1-1/2" x 1-3/8"	120mm x 38mm x 35mm	Mahogany or similar

## CLC Teardrop Camper Hardware List

### Base Kit: Camper Shell

QTY	Description	Metric Equivalent	Application
2	12" - 20" Gas Springs (20lbs)	300mm – 500mm	Galley Hatch
4	SS brackets for gas springs		Galley Hatch
1	Outside Door Handle (clockwise opening)		Doors
1	Outside Door Handle (c.clockwise opening)		Doors
2	Inside Door Handles		Doors
4	Door Lock Actuating rods		Doors
1	Hasp		Galley Hatch
30'	3/4" x 7/16" Foam Hatch Tape	9150mm x 18mm x 11mm	Doors
16'-8"	3/4" Galley Hatch Seal	5080mm x 18mm	Galley Hatch
8	3/8" Fairleads	9mm eye	Doors
4	#8-32 x 5/8" SS Flat Head Machine Screw	4mm x 16mm	Gas Spring Brackets
8	#8-32 Nyloc Nut	4mm	Gas Spring Brackets
8	#8 Finish Washer	4mm	Gas Spring Brackets
4	#8-32 x 3/4" SS Flat Head Machine Screw	4mm x 18mm	Gas Spring Brackets
4	#8-32 x 3/4" SS Flat Head Machine Screw	4mm x 18mm	Galley Hasp
4	#8-32 Nyloc Nut	4mm	Galley Hasp
4	#8 Flat Washer	4mm	Galley Hasp
2	#8-32 x 2" SS Pan Head Machine Screw	4mm x 50mm	Galley Hinges
4	#8 Flat Washer	4mm	Galley Hinges
2	#8-32 Nyloc Nut	4mm	Galley Hinges
4"	1/4" Electrical Heat Shrink	6mm x 100mm	Galley Hinges
6	5/16"-18 x 5" Carriage Bolt	8mm x 127mm	Trailer Bunks
6	5/16" Fender Washer	8mm	Trailer Bunks
6	5/16"-18 Nyloc Nut	8mm	Trailer Bunks
4	#8-32 x 3/4" SS Flat Head Machine Screw	4mm x 18mm	Door Handles
4	#8 Finish Washer	4mm	Door Handles
8	#8 x 1" SS Pan Head Wood Screw	4mm x 25mm	Fairleads: Shell
8	#8 x 1" SS Pan Head Wood Screw	4mm x 25mm	Fairleads: Doors
4	#8-32 x 1-1/2" SS Pan Head Machine Screw	4mm x 38mm	Door Hinges
8	#8 Flat Washer	4mm	Door Hinges
4	#8-32 Nyloc Nut	4mm	Door Hinges
8"	1/4" Electrical Heat Shrink	6mm x 200mm	Door Hinges
2	#8-32 x 3/4" SS Flat Head Wood Screw	4mm x 18mm	Door Pull-Straps
2	#8 Finish Washer	4mm	Door Pull-Straps
64"	1" Wide Black Nylon Strap	1625mm x 25mm	Door Pull-Straps
22	#10-24 x 3/4" SS Flat Head Machine Screw	4.9mm x 18mm	Windows
22	#10 Flat Washer	4.9mm	Windows
22	#10-24 Acorn Nut	4.9mm	Windows
2	#10 x 3/4" SS Flat Head Wood Screw	4.9mm x 18mm	Windows
150'	18-gauge Copper Wire	46m of 1mm copper wire	Shell Assembly

# Choosing Materials

## Plywood

Let's get this out of the way: home-center lauan isn't up to the task. The CLC Teardrop Camper was engineered around the specific properties of marine plywood, which has strong, thick veneers, no voids, and boil-proof glue. There are some pretty big spans in the Camper where there's no framing at all, just a sandwich of marine plywood and fiberglass. Built as specified, that sandwich has enormous strength. You might as well build the camper with wheat thins and honey if you're resolved to use cheap plywood.

Really, as a percentage of the total cost of the project, the difference between cheap and excellent plywood is very small. The camper will be stronger and more durable, the resale value is enhanced, and you will simply enjoy the time you spend working with high-quality materials.

The non-domestic marine plywoods subscribe to a rating system, known as the "British Standard." B.S.1088 is what's desired, especially if it has the "Lloyd's Register" stamp on it. In theory the rating ensures perfect plywood. In practice, these once-hidebound ratings have been watered down a lot in recent years by unscrupulous plywood mills, who stamp their plywood with "BS1088" and "Lloyds" when they have no business doing so. There's little to be done but to examine the panels very closely and stick with major marine ply name-brands of established reputation.

Joubert, a French company, has supplied CLC's plywood for 20 years. Teardrop Camper kits are shipped with BS1088 Lloyd's Register okoume marine plywood.

### Size and Thickness

All plywood panels are assumed to be 48" x 96" (2440x1220mm). If the plywood came from a European mill, it's often a little larger, 98-1/2" x 48" (2500x1220mm). Some of the Teardrop Camper's parts are longer than a typical sheet of plywood and you'll need to cut a few scarf joints, as detailed in these pages later on. A few decades ago it wasn't uncommon to order extra-long marine grade panels, but that option has become costly and rare as of 2017.

One peculiarity of marine grade plywood is that it's always sold in metric thicknesses. The Teardrop Camper has a 4mm-thick shell and an 18mm-thick bottom, with 9mm bulkheads. What if you can't find these thicknesses? Are substitutions acceptable? Yes, but be careful. If you can't get 4mm plywood for the shell, thicker panels might break when you bend them. If you use denser woods (sapele instead of okoume, for example), it's probably okay to go from 4mm to 3mm. If you're not sure, better to shoot us a note and ask.

### Plywood Options

**Sapele** (suh-PEE-lee): Sapele is a tall deciduous tree, a relative of African mahogany. Most of the sapele that finds its way to the United States is harvested in Cameroon.

The veneer has a lovely fudge-ripple-swirl figure that most find irresistible under varnish. Sapele is denser, heavier, and stronger than okoume. Like okoume, sapele is made into plywood at mills all over the world, and panel quality ranges from calamitous to surpassing. It's expensive, so if you're committed to using sapele, look for the Lloyd's Register Type Approval. It's worth a few more bucks.

**Okoume** (oh-KOO-mee): *Aucoumea klaineana* is an African hardwood found in the Congo Basin. It grows in close stands, the trees reaching a height of over 100', the trunks thick and straight. In other words, it's perfect for peeling into plywood veneers.

Okoume is ubiquitous in small-boat construction and it's what we ship with Teardrop Camper kits. The color ranges from blond to reddish-brown, sometimes within the width of a single face veneer. While classified as a hardwood, it's soft, flexible, and very light. A cubic foot weighs just over 25 lbs (11.3kg). As the most popular of the tropical imports, okoume is available in a large variety of thicknesses, from 1.5mm up to 18mm.

Designers always specify an epoxy or fiberglass coating for the relatively soft okoume. Okoume and epoxy belong together like beer and pretzels. Using okoume as a core material in epoxy-composite assemblies results in wondrous feats of engineering: dinghies that weigh 80 lbs, kayaks that weigh 40 lbs, canoes that weigh 30 lbs. We've even cut airplane parts out of it.

Okoume is the easiest to bend of the popular marine plywoods. The Teardrop Camper's shape was determined largely by the curvature that could be achieved easily with 4mm-thick okoume.

**Meranti** (mer-AHN-tee): Meranti belongs to the family *Dipterocarpaceae*, lowland rainforest trees that are native to Southeast Asia. It's a cousin to lauan. Excessive or illegal logging and the fact that some *Dipterocarpaceae* species are endangered has led big-box stores such as Home Depot and Lowes to limit its use in the United States.

Relatively inexpensive in marine-grade spec, meranti appeals to amateur boatbuilders. Thinner panels, such as the 4mm thickness common in kayaks, tend to strain the BS1088 standards if marked as such; this writer has never seen a single thin panel of meranti that he liked. Most meranti is a better fit with the BS6566 stamp. Thicker panels (9mm and up) have a more uniform quality, perhaps because the economics of thicker panels work better for the plywood mills. A thick panel and a thin panel both eat up the same two valuable face veneers, but the mill can charge a lot more for the thick panel.

Meranti is denser and some 10 percent heavier than its competitor, okoume, and a little stronger. It has a dark color sometimes resembling walnut. We've had trouble with the grain of its face veneers tearing when cut. It requires a razor-sharp new cutting bit in the CNC machine at Chesapeake Light Craft.

**Birch Plywood:** If you're striking out on the common marine options, there are birch panels available in the requisite thicknesses. Birch plywood sold for aircraft construction is beautifully clear and, logically, of very high quality. Imported cabinet-grade birch from Scandinavia or Russia is often very nice and perfectly suitable for building a Teardrop Camper, but you'll have lots of knots in the face veneers. (Some may think of this as "character.") Just make sure that the glue is exterior grade.

**Other plywoods:** Paulownia plywood is starting to make waves. Its properties rival okoume, and I hope it becomes more common. Likewise I hope someone comes up with a commercially viable bamboo plywood one of these days. At the moment the bamboo plywoods that are out there are ridiculously expensive, and simply too stiff for this design. Maybe someday. As for construction grade plywood: sorry. There are simplistic designs that can be nailed together from AC fir and even, heaven forbid, lauan, but the CLC Teardrop Camper is not one of them. It has too much shape in the panels and too many wide spans of plywood to risk anything other than first-rate marine grade plywood.

## Epoxy

You are limited to marine-grade epoxy systems in building the CLC Teardrop Camper, as it was designed around the mechanical properties of high-quality epoxy. Polyester or vinylester resin won't do it. Nor will polyurethane adhesives work for joinery, unless you want a fragile and disposable camper.

If you're new to epoxy, the options available just within the marine segment are bewildering. Let's make it easier by limiting our choices only to epoxy systems that are *amine-blush-free*.

"Amine blush" is a phenomena intrinsic to a whole generation of epoxy brands, in which the organic compound amine reacts with atmospheric carbon dioxide and humidity and forms a greasy film on the surface of the epoxy as it cures. Until you scrub it off, this greasy film will defy all subsequent attempts at bonding more epoxy or varnish or paint to the surface.

25 years ago we just lived with amine blush, cleaned it off with soap and water or nasty-smelling solvents, and endured failed bonds when we weren't scrupulous in our clean-up.

In 2017 we don't have to worry about it much, because all of the major brands offer blush-free epoxy systems. More costly? Yes, but only a little, and inconsequential in comparison to the total cost of the project and the hassles spared.

The assembly manual *How to Build the CLC Teardrop Camper* assumes that you're using blush-free epoxy.

At CLC we use **MAS Epoxy** for almost everything; that's what is shipped with Teardrop Camper kits. Its low viscosity makes fiberglass work especially forgiving. The Slow Hardener used with MAS Epoxy resin gives you the longest working time of any name-brand epoxy. It also has the least odor, an important practical consideration when building at home.

**WEST Systems** epoxy has been around the longest and is practically synonymous with the idea of marine epoxy. It's widely available and WEST offers terrific technical support. We like and often use WEST Systems 105 resin with the 207 Hardener. (The 205 and 206 Hardeners blush, so be careful.)

**System Three** makes a blush-free epoxy called SilverTip. We've used a lot of SilverTip with good results.

Whichever epoxy you choose, proceed with caution and ask around for opinions, especially if you haven't used epoxy before. You want epoxy that's easy to use and produces clear finishes over wood and fiberglass.

See *How to Build the CLC Teardrop Camper* for extensive discussion about using epoxy and its various additives.

## Fiberglass

Fiberglass is just what it sounds like: Extruded fibers of melted glass—the same silicon glass that's in a window pane—spun into yarns and woven into a fabric with the texture of burlap. (And a tendency to make you insanely itchy. Wear gloves when you work with this stuff.)

The CLC Teardrop Camper is basically a fiberglass shell with a plywood core. Most of the strength derives from the fiberglass reinforcement, so it's not optional.

Fiberglass fabrics are distinguished by their weight, measured in ounces per square yard. (Or grams per square meter.) Fabric for the Teardrop Camper is specified at 6 ounces/sq. yard (203grams/sq.m). We cut all of ours from 50" wide (127cm) rolls of cloth. Fiberglass is a commodity and available just about everywhere, but you should buy it from a trusted marine supplier. Fiberglass intended to be saturated with resin has been treated with special chemicals (called "sizing") that improve its workability.

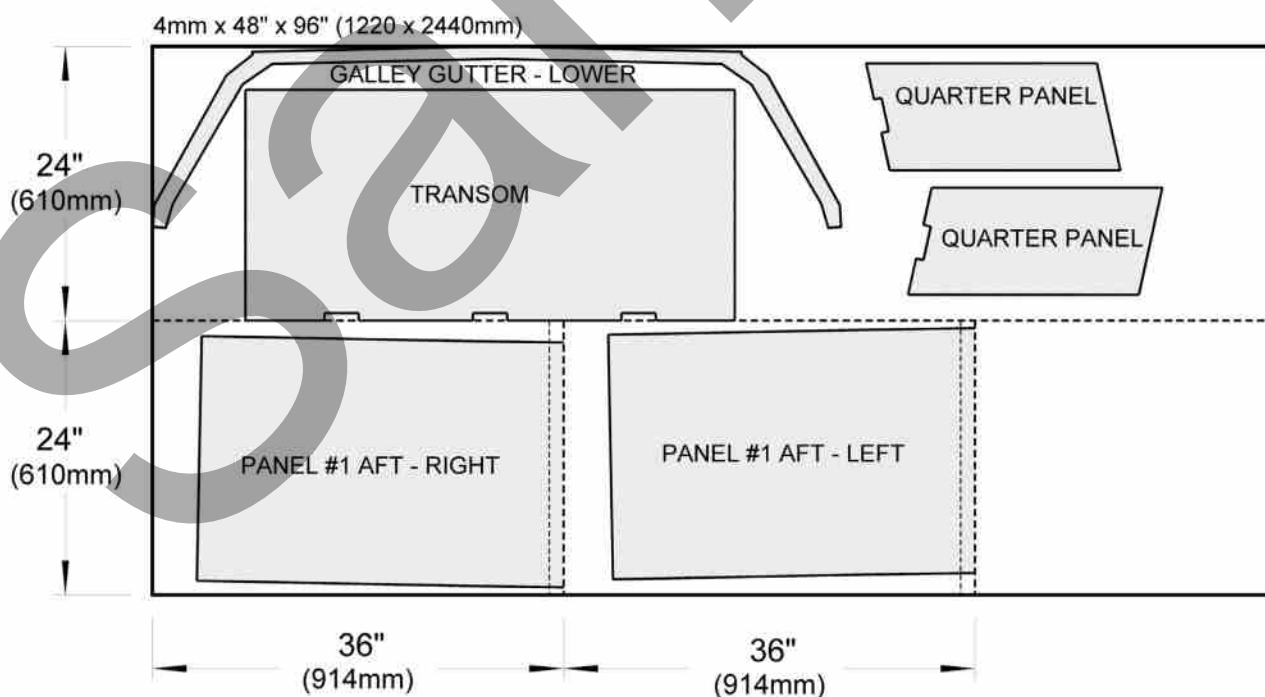
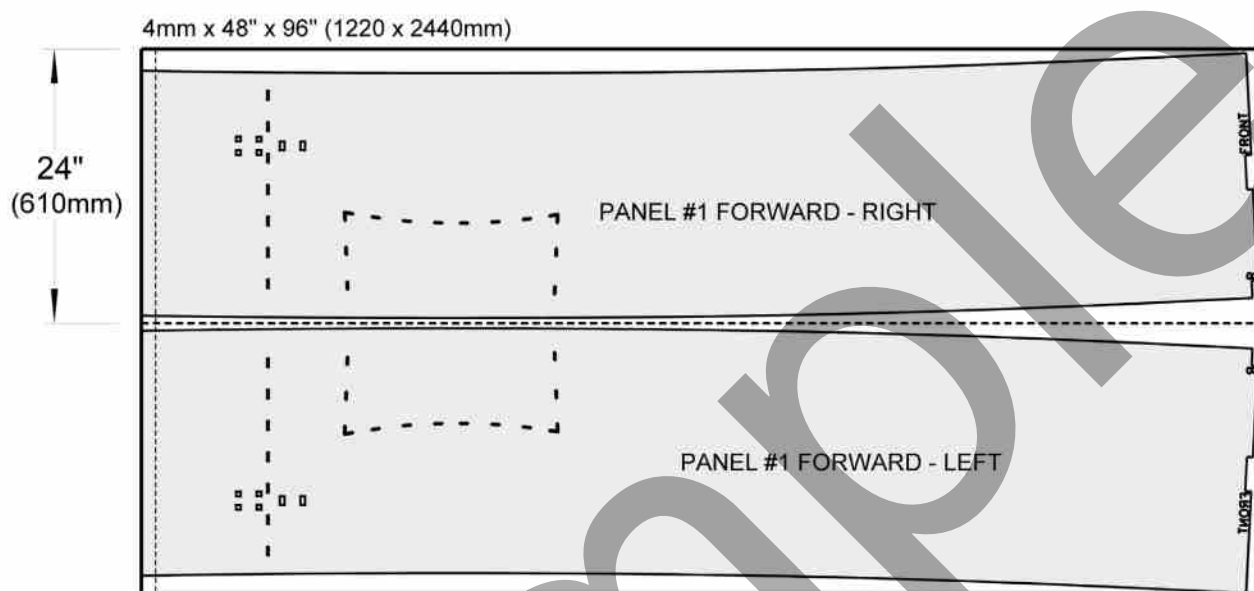
You'll also need fiberglass tape in a 9-ounce weight, 3 inches wide (305grams/sq.m, 76mm wide). Plainwoven tape is fine in this application. There's no need to upgrade to the fancier biaxial-weave variants.



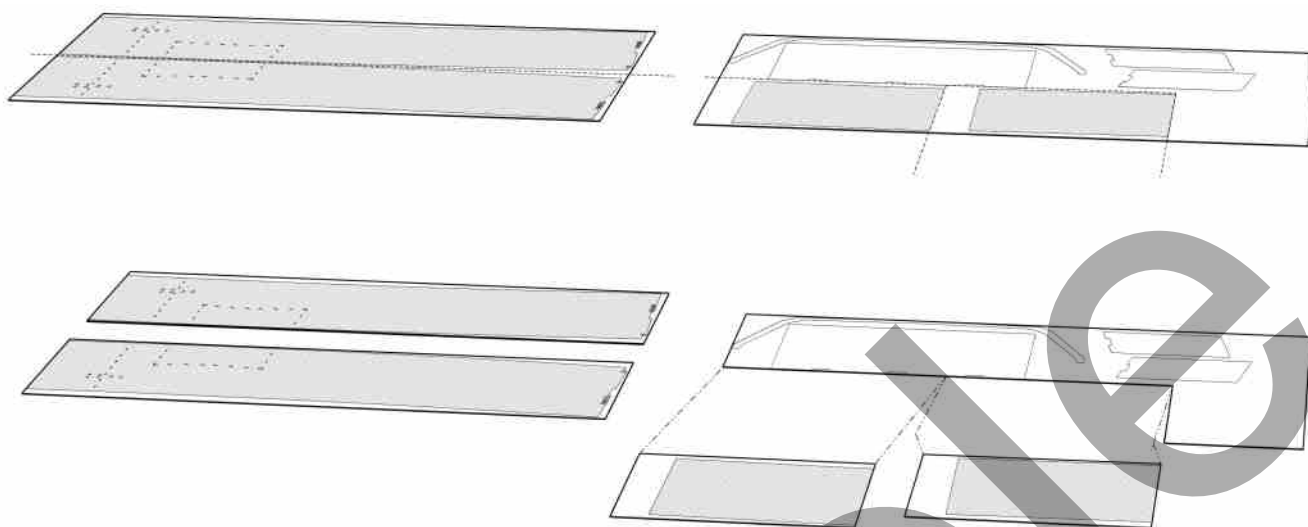
# Plywood Layout Guide

## Creating 4mm Plywood "Blanks"

The shell of the camper is built of 4mm marine plywood. Panels #1 and #2 are longer than a sheet of plywood and thus need to be pieced together from shorter sections. Before you transfer the shapes from the patterns, you'll create "blanks," from which the finished parts will be cut.



The diagrams on Page 399 and below show you how to divide up two sheets of 4mm plywood, then cut "scarf joints" to create blanks.

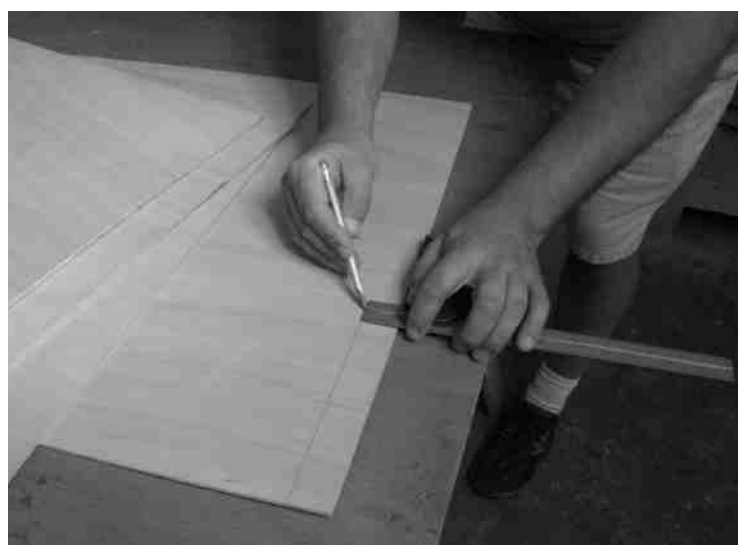


Scarf joints intimidate some builders, but they are easy once you set plane to wood and just do it. Scarfs should have an 8:1 ratio, or about 1-1/4" (32mm) long in 4mm plywood. We have the best results cutting scarfs with a sharp plane. We've also experimented with beltsanders and grinders for cutting scarfs; they never achieve the same precision as a good sharp plane, and aren't any faster. If your plane is dull you might as well chew the scarfs into the panels with your teeth. (Look for plane-sharpening tips on our website.)

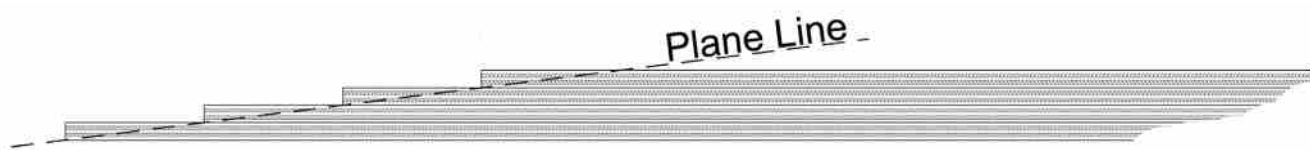


*A scarf joint, shown here in cross-section, is a strong and reliable way to join sheets of plywood.*

Having created four rectangular blanks for the #1 Panels (two longs and two shorts), draw a line 1-1/4" (32mm) from the end of each blank with a straight-edge or tri-square.



Stack all four blanks in stair-step fashion as shown in the side view below. You'll be able to plane all four scarfs at one time.



Here are four blanks stacked up and aligned, ready for planing. The bottom-most blank is aligned with the end of the workbench for support.

The stick of wood is a clamp, screwed down to the workbench to keep the blanks from sliding around.



You don't need a fancy plane. A small "block plane" like this one is perfectly adequate, as long as it's sharp.



Set to it with your plane.



You can use the side of your block plane as a handy straight-edge to check the uniformity of the “ramp” you’re planing.

Use the revealed glue lines as a guide to remove material evenly.



Finish the last bit with 80-grit sandpaper on a sanding block.



Finished scarfs will have neat, parallel plywood glue lines. The glue lines are a big help in cutting uniform scarf joints.

